# BS EN 4540:2011



# **BSI Standards Publication**

Aerospace series — Bearings, spherical plain, in corrosion resisting steel with self-lubricating liner elevated load under low oscillations — Technical specification



BS EN 4540:2011 BRITISH STANDARD

#### National foreword

This British Standard is the UK implementation of EN 4540:2011.

The UK participation in its preparation was entrusted to Technical Committee ACE/12, Aerospace fasteners and fastening systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

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ISBN 978 0 580 65443 5

ICS 49.035

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2012.

Amendments issued since publication

Date Text affected

# EUROPEAN STANDARD NORME EUROPÉENNE EUROPÄISCHE NORM

EN 4540

December 2011

ICS 49.035

#### **English Version**

# Aerospace series - Bearings, spherical plain, in corrosion resisting steel with self-lubricating liner elevated load under low oscillations - Technical specification

Série Aérospatiale - Rotules, en acier résistant à la corrosion à garniture autolubrifiante à charge élevée sous faibles oscillations - Spécification technique

Luft- und Raumfahrt - Gelenklager aus korrosionsbeständigem Stahl mit selbstschmierender Beschichtung, hohe Belastung bei geringer Drehbewegung - Technische Lieferbedingungen

This European Standard was approved by CEN on 24 March 2011.

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EUROPEAN COMMITTEE FOR STANDARDIZATION COMITÉ EUROPÉEN DE NORMALISATION EUROPÄISCHES KOMITEE FÜR NORMUNG

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#### **Foreword**

This document (EN 4540:2011) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2012, and conflicting national standards shall be withdrawn at the latest by June 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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#### 1 Scope

This European Standard specifies the required characteristics, inspection and test methods, qualification and acceptance conditions for spherical plain bearings in corrosion resisting steel, self aligning with self-lubricating liner designed to withstand (under load) slight swivelling and slow rotations only.

This standard applies whenever referenced.

These bearings prEN 4538-1, prEN 4538-2, prEN 4539-1 and prEN 4539-2 are for actuator applications and for use in the temperature range - 54 °C to 163 °C and for EN 4538-003 and EN 4539-003 for use in the temperature range - 54 °C to 120 °C.

The liner may be of a fabric or composite material bonded to the inside diameter of the outer ring or in a composite material moulded into a pre-formed cavity between the inner and outer rings.

The duty cycle (Annex E, normative) has been established on the basis of a civil aircraft aileron surface application.

#### 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

prEN 4538-1, Aerospace series — Bearings, spherical plain, in corrosion resisting steel with self-lubricating liner — Elevated load under low oscillations — Narrow series — Dimensions and loads — Metric series <sup>1)</sup>

prEN 4538-2, Aerospace series — Bearings, spherical plain, in corrosion resisting steel with self-lubricating liner — Elevated load under low oscillations — Narrow series — Dimensions and loads – Inch series <sup>1)</sup>

EN 4538-003, Aerospace series — Bearings, spherical plain, in corrosion resisting steel with self-lubricating liner elevated load under low oscillations — Narrow series — Dimensions and loads — Part 003: Inch series with low friction coefficient

prEN 4539-1, Aerospace series — Bearings, spherical plain, in corrosion resisting steel with self-lubricating liner — Elevated load under low oscillations — Wide series — Dimensions and loads — Metric series <sup>1)</sup>

prEN 4539-2, Aerospace series — Bearings, spherical plain, in corrosion resisting steel with self-lubricating liner — Elevated load under low oscillations — Wide series — Dimensions and loads — Inch series <sup>1)</sup>

EN 4539-003, Aerospace series - Bearings, spherical plain, in corrosion resisting steel with self-lubricating liner elevated load under low oscillations - Wide series - Dimensions and loads - Part 003: Inch series with low friction coefficient

EN 9133, Aerospace series — Quality management systems — Qualification procedure for aerospace standard parts

ISO 11078, Aircraft — De-icing/anti-icing fluids, ISO types II, III and IV

TR 4475, Aerospace series — Bearings and mechanical transmissions for airframe applications — Vocabulary 2)

<sup>1)</sup> Published as ASD-STAN Prestandard at the date of publication of this standard by Aerospace and Defence Industries Association of Europe-Standardization (ASD-STAN), (www.asd-stan.org).

<sup>2)</sup> Published as ASD-STAN Technical report at the date of publication of this standard by Aerospace and Defence Industries Association of Europe-Standardization (ASD-STAN), (www.asd-stan.org).

#### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

#### 3.1

# self-lubricated spherical plain bearings, self-aligning in corrosion resistant steel with staking groove for actuator applications

these consist of two concentric rings, between which is interposed a self-lubricating liner which is bonded or moulded on the spherical surface of the outer ring.

The width of the inner ring is greater than the width of the outer ring, so that a tilting movement is possible in addition to the rotational movement.

The outer ring has no assembly slot.

This outer ring has grooves for mechanical swaging

#### 3.2

#### surface discontinuities

see TR 4475

#### 3.3

# starting torque without load

see TR 4475

#### 3.4

#### friction coefficient

the friction coefficient of the bearing under load is given by the following formula:

$$\mu = \frac{C}{FR}$$

where

 $\mu$  friction coefficient;

C torque moment;

F load on the bearing;

R inner spherical ball radius.

#### 3.5

#### permissible radial static loads radial ( $C_s$ )

this corresponds to a permissible unit pressure multiplied by the projected surface area, the inner ring being able to take any position within the limits of the tilting angle indicated in the product standards or design documentation.

The direction of the load shall remain in the center plane of the outer ring.

The radial projected surface area is given by the following formula:

$$A_r = K (C \min - 2 T \max)$$

Where the dimensions shown in Figure 1 are as given in the appropriate product standard

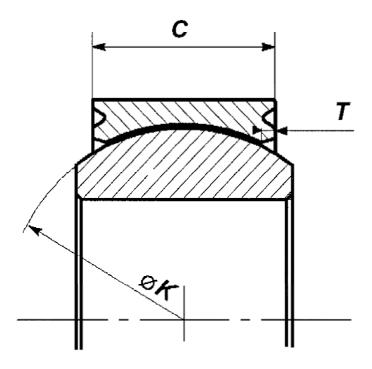


Figure 1

#### 3.6

#### dynamic radial load (oscillatory duty cycles)

load which may be withstood by a bearing submitted to an oscillating movement following a given number and frequency of cycles, without the wear of the self-lubricating liner exceeding the values given in this standard

#### 3.6.1

#### oscillating duty cycles

are defined in Annex E. The table defines unit pressure applied.

The dynamic radial load is defined for each bearing size by multiplying the unit pressure by the projected surface area, see dimensional standard

#### 3.6.2

# dynamic radial load $C_{25}$

one oscillating cycle includes an angular displacement of the inner ring in relation to the outer ring from  $0^{\circ}$  to  $25^{\circ}$ , then from  $25^{\circ}$  to  $-25^{\circ}$  and finally  $-25^{\circ}$  to  $0^{\circ}$ 

#### 3.6.3

# dynamic radial load $C_{250}$

one oscillating cycle includes an angular displacement of the inner ring in relation to the outer ring from  $0^{\circ}$  to  $25^{\circ}$ , then from  $25^{\circ}$  to  $-25^{\circ}$  and finally  $-25^{\circ}$  to  $0^{\circ}$ 

#### 3.7

# adhesion of the liner - Void

area where the adhesive bond is broken or non-existent and leaves a smooth and clean interface on the metallic surface

#### 3.8

#### delivery batch

this consists of bearings with the same identity block, which may come from different production batches

# 3.9ultimate static loadsis equivalent to 1,5 times the permissible static load

# 4 Required characteristics, inspection and test methods

See Table 1.

Table 1

Clause	Characteristics	Requirements	Inspection and test methods	<b>Q</b> a	<b>A</b> b
4.1	Materials	Shall conform with the product standards or design documentation.	Chemical analysis or certificate issued by semi-finished product manufacturer	Χ	Х
4.2	Dimensions and tolerances	Shall conform with the product standards or design documentation.  Dimensions not shown shall be at the manufacturer's option.	Suitable measuring instruments  Measurement of bore and outer diameter:  — rings with a width of ≤ 10 mm: in the center plane;  — rings with a width of > 10 mm: in two planes parallel to the outer faces and at a distance from these faces of twice the maximum value of the ring chamfer. The minimum and maximum diameters shall be determined in each measuring plane.  Measurement of ring width:  — the width of each ring (distance between the two faces) shall be verified at	X	X
			a minimum of four points.		
4.3	Masses	Shall conform with the product standards or design documentation.	Suitable methods	Χ	
4.4	Marking	Shall conform with the product standards or design documentation. It shall be legible and shall not adversely affect the material or the functioning of the bearing.	Visual examination	Х	X
4.5	Surface appearance	<ul> <li>the bearings shall be free of surface discontinuities liable to have an adverse effect on their characteristics and endurance;</li> <li>the liner shall not contain contaminant products and shall not show broken or voided areas;</li> <li>lubrication shall not be permitted.</li> </ul>		X	X
4.5.1	Assembled bearings		Visual inspection using suitable methods		
4.5.2	Unassembled rings		Magnetic or dye penetrant inspection		
4.6	Hardness	Shall conform with the product standards or design documentation.	Suitable processes and measuring instruments	Х	Х
4.7	Surface roughness	Shall conform with the product standards or design documentation.	Suitable measuring instruments or visual-tactile samples	Х	Х
4.8	Surface treatment	Shall conform with the product standards or design documentation.	<ul><li>Visual inspection;</li><li>As per surface treatment standard.</li></ul>	Х	Х
4.9	Behaviour in rotation and tilt	Bearings shall be able to move freely within the angular limits specified in the product standards or design documentation.	Manual inspection	Х	Х

continued

Table 1 (continued)

Clause	Characteristics	Requirements	Inspection and test methods	Q ª	<b>A</b> b
4.10	Starting torque without load	_	-	_	_
4.10.1	<ul> <li>at ambient temperature.</li> </ul>	Shall conform with the product standards or design documentation.	Suitable processes and measuring instruments:	Х	Х
			<ul> <li>Measurement of the starting torque shall be preceded by some rotations and a few turning movements by hand;</li> </ul>		
			<ul> <li>Measure the torque, applied gradually to the inner ring, in both directions, with the outer ring held stationary. Read off the maximal value required to start up the inner ring.</li> </ul>		
4.10.2	<ul> <li>at low temperature.</li> </ul>	Starting torque $\leq 2$ times those listed in the product standards or design documentation.	<ul> <li>Subject the bearing, during 4 h at the minimum temperature ± 5 °C;</li> </ul>	Х	
			Immediately after, measure the torque following 4.10.1.		
4.10.3	<ul> <li>after limit temperatures.</li> </ul>	Shall conform with Tables 2 (a) and 2 (b).	– Subject the bearing during 1 h at the minimum temperature $\pm$ 5 °C, then 1 h at the maximum temperature $\pm$ 2 °C;	X	
			<ul> <li>Repeat successively × 10 this test;</li> </ul>		
			<ul> <li>4 h after these tests, measure the torque, at ambient temperature, following 4.10.1.</li> </ul>		
4.11	Spherical surfaces	For bonded liners: Difference between the values measured	Encapsulate the bearing in plastic material as used in metallurgical mounts.	Х	
C	conformity		Section the bearing following a diameter plane and polish the surfaces (see Figure 2).		
			By use of an optical comparator, for example, measure dimension "t" at a minimum of five uniformly spaced positions across the bearing (see Figure 2) on both opposite surfaces. The selected points shall include the middle position of the bearing at the C/10 positions.		
		For injected/moulded liners: the maximum thickness of the liner shall be	Encapsulate the bearing in plastic material as used in metallurgical mounts.	Х	
		located between the <i>C</i> /10 positions.  The minimum thickness shall be 0,2 mm.	Section the bearing following a diameter plane and polish the surfaces		
		,	By use of an optical comparator, for example, measure dimension "t" at a minimum of five uniformly spaced positions across the bearing (see Figure 2) on both opposite surface. The selected points shall include the middle position of the bearing at the C/10 positions.		
4.12	Permissible static loads:	Shall conform with the product standards or design documentation.	See Annex A.	Х	
	– radial: $C_s$ ;	No maximum total deflection greater than those listed in Tables 3 (a) and 3 (b) under permissible static loads ( $C_s$ ).			
	– axial: $C_a$ .	After removing the loads, no permanent deformations greater than those listed in Tables 3 (a), 3 (b) and 3 (c).			
4.13	Ultimate static loads: - radial;	After the removal of the loads, there shall be no cracks, no push out of the inner ring or deterioration of the bearing.	See Annex A.	Х	

continued

Table 1 (continued)

Clause	Characteristics	Requirements	Inspection and test methods	Q a	A b
4.14 A	Dynamic radial loads $C_{25}$ :	Shall conform with the product standards or design documentation.	See Annex B.	Х	
	- at low	After the removal of the loads:			
	temperature;  – at high	<ul> <li>No metal-to-metal contact between inner and outer ring;</li> </ul>			
	temperature.	<ul> <li>The liner wear shall not exceed the values listed in Table 4;</li> </ul>			
		<ul> <li>The peel-strength and the bond integrity shall be conform with 4.16 and 4.17.</li> </ul>			
		At the end of this test, the starting torque under radial load shall be measured and shall conform with values listed in Tables 5 (a), 5 (b) and 5 (c).	Suitable processes and measuring instruments		
4.14 B	Dynamic radial loads $C_{250}$ : for EN 4538-003 and EN 4539-003	Shall conform with the product standards or design documentation. After the removal of the loads:  — No metal-to-metal contact between inner and outer ring;  — The liner wear shall not exceed the	See Annex F.		
	- at low temperature;	values listed in Table 4;  — The peel-strength and the bond integrity shall be conform with 4.16 and 4.17.	Suitable processes and measuring		
	- at high temperature.	At the end of this test, the starting torque under radial load shall be measured and shall conform with values listed in Tables 5 (a), 5 (b) and 5 (c).	instruments		
4.14 bis	Dynamic radial loads duty cycles:  – at ambient temperature.	Shall conform with the duty cycles. After the removal of the loads:  - No metal-to-metal contact between inner and outer ring;  - The liner wear shall not exceed the values listed in Table 4;  - The peel-strength and the bond integrity shall be conform with 4.16 and 4.17.  At the end of this test, the starting torque under radial load shall be measured and shall conform with values listed in Tables 5 (a), 5 (b) and 5 (c).	See Annex E.	x	
	Low friction coefficient for EN 4538-003 and or EN 4539-003	Coefficient of friction to be measured before and completion of the duty cycles test at $-$ 54 °C, $-$ 30 °C, $-$ 10 °C and ambient temperature. For each temperature three measurements must be taken at 10 MPa, 60 MPa and 120 MPa pressure. The maximum value of coefficient of friction is $\mu$ = 0,18.	See Annex G.		

continued

Table 1 (concluded)

Characteristics	Requirements	Inspection and test methods	<b>Q</b> a	<b>A</b> b
Liner compatibility with the fluids	At the end of this test:  - No metal-to-metal contact between inner and outer ring;  - The liner wear shall not exceed the values listed in Table 4;  - The peel strength and the bond integrity shall be conform with 4.16 and 4.17;  - The starting torque under radial load shall be measured and shall conform with values listed in Tables 5 (a), 5 (b) and 5 (c).	Check one bearing per fluid:  Put the inner ring perpendicularly to the outer ring;  The bearing shall be immersed for 24 h in the fluids listed in Annex C at the following temperatures:  (45 ± 3) °C for those defined in C.1 and C.2,  (70 ± 3) °C for those defined in C.3,  Ambient temperature for those defined in C.4;  Within 1/2 h after this test proceed to the test defined in B.2.4.  Suitable processes and measuring	X	
Peel strength of the liner	These requirements and this test apply only in the case where the manufacturer has established that the liner is peelable.  The liner shall exhibit an average peel strength greater than 0,35 N for each millimetre of spherical width minus 2 mm to eliminate chamfers and edge effects.  The mean peel strength value shall be determined with at least 75 % of the recorded value.	instruments  See Annex D.  For acceptance, this test shall be carried out immediately after assembling and curing.	X	X
Bond integrity	For peelable liners, the liner:  - shall not contain any contaminating substances;  - shall adhere tightly to the outer ring over at least 90 % of the contact area.  No void shall be allowed which cannot be described within a circle of diameter equal to:  - 25 % of outer ring width;  - 6 mm,  whichever is smaller.  For non-peelable liners, a sectioned bearing shall be examined for bond integrity. The liner:  - shall adhere tightly to the outer ring over at least 90 % of the contact area.  No void shall be allowed which cannot be circumscribed within a circle of diameter equal to:  - 25 % of outer ring width;	After the peel strength test, evaluate the location and size of any voids.  Destructively examine the liner by chipping, scraping, abrasion, or other appropriate means to determine the bond integrity.	X	Х
	Liner compatibility with the fluids  Peel strength of the liner	Liner compatibility with the fluids  At the end of this test:  No metal-to-metal contact between inner and outer ring;  The liner wear shall not exceed the values listed in Table 4;  The peel strength and the bond integrity shall be conform with 4.16 and 4.17;  The starting torque under radial load shall be measured and shall conform with values listed in Tables 5 (a), 5 (b) and 5 (c).  Peel strength of the liner  These requirements and this test apply only in the case where the manufacturer has established that the liner is peelable.  The liner shall exhibit an average peel strength greater than 0,35 N for each millimetre of spherical width minus 2 mm to eliminate chamfers and edge effects.  The mean peel strength value shall be determined with at least 75 % of the recorded value.  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No void shall be allowed which cannot be circumscribed within a circle of diameter equal to:	Liner compatibility with the fluids  At the end of this test:  — No metal-to-metal contact between inner and outer ring;  — The liner wear shall not exceed the values listed in Table 4;  — The peel strength and the bond integrity shall be conform with 4.16 and 4.17;  — The starting torque under radial load shall be measured and shall conform with values listed in Tables 5 (a), 5 (b) and 5 (c).  Peel strength of the liner  These requirements and this test apply only in the case where the manufacturer has established that the liner is peelable.  The liner shall exhibit an average peel strength greater than 0.35 N for each millimetre of spherical width minus 2 mm to eliminate chamfers and edge effects.  The mean peel strength value shall be determined with at least 75 % of the recorded value.  Bond integrity  For peelable liners, the liner:  — shall not contain any contaminating substances;  — shall adhere tightly to the outer ring over at least 90 % of the contact area.  No void shall be allowed which cannot be described within a circle of diameter equal to:  — 25 % of outer ring width; — 6 mm, — whichever is smaller.  For non-peelable liners, a sectioned bearing shall be examined for bond integrity. The liner: — shall adhere tightly to the outer ring over at least 90 % of the contact area.  No void shall be allowed which cannot be circumscribed within a circle of diameter equal to:  — 25 % of outer ring width; — 6 mm, — whichever is smaller.  For non-peelable liners, a sectioned bearing shall be examined for bond integrity. The liner: — shall adhere tightly to the outer ring over at least 90 % of the contact area.  No void shall be allowed which cannot be circumscribed within a circle of diameter equal to:  — No void shall be allowed which cannot be circumscribed within a circle of diameter equal to: — 25 % of outer ring width; — 6 mm, — whichever is smaller.  For non-peelable liners, a sectioned bearing shall be examined for bond integrity. The liner: — shall adhere tightly to the outer ring over at least 90 %	Liner Compatibility with the fluids  At the end of this test:  - No metal-to-metal contact between inner and outer ring:  - The liner wear shall not exceed the values listed in Table 4;  - The peel strength and the bond integrity shall be conform with 4-16 and 4-17;  - The starting forque under radial load shall be measured and shall conform with values listed in Tables 5 (a), 5 (b) and 5 (c).  Peel strength of the liner  These requirements and this test apply only in the case where the manufacturer has established that the liner is peelable.  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The liner:  - shall adhere tightly to the outer ring over at least 90 % of the contact area.  No void shall be allowed which cannot be circumscribed within a circle of diameter equal to:  - 25 % of outer ring width;  - 6 mm, whichever is smaller.  For non-peelable liners, a sectioned bearing shall be examined for bond integrity. The liner:  - shall adhere tightly to the outer ring over at least 90 % of the contact area.  No void shall be allowed which cannot be circumscribed within a circle of diameter equal to:

Table 2 (a)

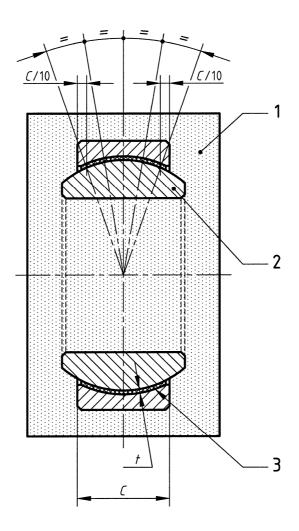
Nominal diameter	Metric series Starting torque at zero load N.m		
mm	EN 4538-1	EN 4539-1	
12			
15	0,072 to 0,80	0.072 to 0.90	
17		0,072 to 0,80	
20	_		
22	0.15 to 1.0	_	
25	0,15 to 1,0	0,15 to 1,0	
30		0.24 to 2.0	
35	0,24 to 2,0	0,24 to 2,0	
40			
45	0.26 to 2.50	0.26 to 2.50	
50	0,36 to 3,50	0,36 to 3,50	
55	_		

Table 2 (b)

Code	Nominal diameter	Inch series Starting torque at zero load N.m		
	mm	EN 4538-2	EN 4539-2	
03	4,83	0,036 to 0,34	0,036 to 0,34	
04	6,35			
05	7,94			
06	9,52			
07	11,11	0,066 to 0,56	0,036 to 0,34	
08	12,70	0,000 to 0,50	0,030 to 0,34	
09	14,29			
10	15,87			
12	19,05			
14	22,22	0 129 to 0 00	0 129 to 0 00	
16	25,40	0,138 to 0,90	0,138 to 0,90	
20	31,75			
24	38,10	0,24 to 1,50	0 120 to 1 00	
28	44,45		0,138 to 1,80	
32	50,80	_		

Table 2 (c)

Code	Nominal diameter	Inch series Starting torque at zero load N.m		
	mm	EN 4538-003	EN 4539-003	
03	4,83	0,06 to 0,56	0,06 to 0,56	
04	6,35			
05	7,94			
06	9,52			
07	11,11			
08	12,70	0 11 to 0 00	0.11 to 0.00	
09	14,29	0,11 to 0,90	0,11 to 0,90	
10	15,87			
12	19,05			
14	22,22			
16	25,40			
20	31,75			
24	38,10	0,23 to 1,50	0.23 to 1.50	
28	44,45		0,23 to 1,50	
32	50,80	_		



- 1 Plastic encapsulation
- 2 Bearing
- 3 Liner

Figure 2

Table 3 (a)

Dimensions in millimetres

	Maximum total	Maxim	ıum permai	nent deforr	nation
Nominal	deflection	EN 4	EN 4538-1		539-1
diameter	under load	After	load	After	load
	$C_{s}$	$C_{s}$	$C_{a}$	$C_{s}$	$C_{a}$
12	0,37				
15	0,43	0,08	0,12	0,08	0,12
17	0,43			0,06	0,12
20					
22	0,50	0,08	0,12	_	_
25		0,06	0,12	0,10	0,14
30					
35	0,75	0,10	0,14		
40				0,12	0,16
45	1,00	0.12	0,16	0,12	0,10
50	1,00	0,12	0,10		
55	<u> </u>	_	_		

Table 3 (b)

Dimensions in millimetres

		Maximum total	Maxim	num perma	nent deforr	nation
Code	Nominal	deflection	EN 4538-2		EN 4	539-2
Code	diameter	under load	After	load	After	load
		$C_{s}$	$C_{\mathtt{s}}$	$C_{a}$	$C_{s}$	$C_{a}$
03	4,826					
04	6,350	0.05				
05	7,937	0,25				
06	9,525					
07	11,113	0.39				
08	12,700	0,38	0,08	0,127	0,08	0,127
09	14,288	0,43				
10	15,875	0,43				
12	19,050					
14	22,225	0,50				
16	25,400					
20	31,750	0.75	0,10	0,14	0,10	0,14
24	38,100	0,75	0.12	0.16		
28	44,450	1,00	0,12	0,16	0,12	0,16
32	50,800	1,00	_	_		

Table 3 (c)

Dimensions in millimetres

		Maximum total	Maxim	num perma	nent deforn	nation
Code	Nominal	deflection	EN 45	38-003	EN 45	39-003
Code	diameter	under load	After	load	After	load
		$C_{s}$	$C_{s}$	$C_{a}$	$C_{\mathtt{s}}$	$C_{a}$
03	4,826					
04	6,350	0.20				
05	7,937	0,20				
06	9,525					
07	11,113	0.30				
08	12,700	0,30	0,06	0,11	0,06	0,11
09	14,288	0.42				
10	15,875	0,43				
12	19,050					
14	22,225	0,43				
16	25,400					
20	31,750	0.65	0,09	0,12	0,09	0,12
24	38,100	0,65	0.11	0.14		
28	44,450	0.0	0,11	0,14	0,11	0,14
32	50,800	0,9	_	_		

Table 4

	Maximum permissible liner-wear		
Test under dynamic radial loads	EN 4538-2/EN 4539-2 C <sub>25</sub> mm	EN 4538-003/EN 4539-003 $C_{250}$ mm	
C <sub>25</sub> at low temperature	0,20	0.45	
C <sub>25</sub> at high temperature		0,15	
$C_{25}$ at ambient temperature after immersion in the fluids	0,15	0,10	
Duty cycle at ambient temperature			

Table 5 (a)

Nominal diameter	Maximum starting N.	•
mm	EN 4538-1	EN 4539-1
12	21,28	35,68
15	42,55	48,77
17	54,68	60,16
20	_	90,55
22	128,87	_
25	157,53	296,10
30	244,87	390,62
35	353,21	483,68
40	476,42	563,86
45	667,04	760,31
50	883,26	956,72
55	_	1 331,07

Table 5 (b)

Code	Nominal diameter	•	torque under load .m
	mm	EN 4538-2	EN 4539-2
03	4,826	2,4	7.40
04	6,350	5,1	7,40
05	7,937	9,1	10,20
06	9,525	12,5	17,00
07	11,113	17,0	26,00
08	12,700	24,8	36,80
09	14,288	33,4	51,50
10	15,875	48,0	61,00
12	19,050	85,4	98,70
14	22,225	118,1	130,00
16	25,400	198,0	302,00
20	31,750	245,0	390,00
24	38,100	475,0	565,00
28	44,450	670,0	760,00
32	50,800	_	960,00

Table 5 (c)

Code	Nominal diameter	_	torque under load m
	mm	EN 4538-003	EN 4539-003
03	4,826	1,5	1,5
04	6,350	4,0	4,5
05	7,937	6,8	7,7
06	9,525	9,4	12,8
07	11,113	12,8	19,5
08	12,700	18,6	27,6
09	14,288	25,0	38,6
10	15,875	36,0	45,8
12	19,050	64,0	74,0
14	22,225	88,6	97,5
16	25,400	149,0	227,0
20	31,750	184,0	293,0
24	38,100	356,0	424,0
28	44,450	503,0	570,0
32	50,800	_	720,0

#### 5 Quality assurance

#### 5.1 Product qualification

See EN 9133 and Tables 6, 7, 8 (a), 8 (b) and 8 (c).

Qualification shall be obtained for each bearing.

However, qualification is acquired if it has been obtained, for the bearing immediately before and the one immediately after the bearing in question, within the range of bearings indicated in the product standard.

#### 5.2 Acceptance conditions

#### 5.2.1 Inspections and tests to be carried out by the manufacturer

The acceptance of a delivery batch shall be in accordance with Table 9.

# 5.2.2 User's quality control

The user may, on acceptance of a delivery batch, proceed to inspect it by using the inspections specified in Table 9, in full or in part, to ensure that the items conform to the required quality level, and to determine whether the delivery batch is acceptable.

This inspection can be carried out in the user's factory, or, by special agreement, in the manufacturer's factory.

#### 6 Packaging

The bearings shall be packaged either individually or in rolls so that they will not be damaged during transportation.

They shall be protected against moisture, corrosion, dirt and other harmful substances.

The packaging material in contact with the bearing shall provide this protection.

The following indications shall be affixed to each individual package:

- Manufacturer's name and address;
- Quantity (for rolls);
- Identity blocks as defined by product standards or design documentation;
- Packaging date.

The following indications at least must appear on collective packaging:

- Manufacturer's name and address;
- Number of order;
- Quantity;
- Identity block as defined by the product standards or design documentation.

# 7 Certificate of conformity

All the bearings supplied in accordance with this standard shall be accompanied by a certificate of conformity from the manufacturer.

Table 6 — Non-destructive inspections and tests to be carried out for qualification

Type of inspe	ections and tests <sup>a</sup>	Defined				Se	rial	num	ber	of sa	ampl	es			
		in subclause	1	2	3	4	5	6	7	8	9	10	11	12	13
Materials		4.1	Χ	Χ	Χ	Χ	Χ								
Dimensions and	d tolerances	4.2	Χ	Χ	Χ	Χ	Χ								
Masses		4.3	Χ	Χ	Χ	Χ	Χ								
Marking	4.4	Χ	Χ	Χ	Χ	Χ									
Surface appearance		4.5	Χ	Χ	Χ	Χ	Χ								
Hardness		4.6	Χ	Χ											
Surface roughn	ess	4.7	Χ	Χ	Χ	Χ									
Surface treatme	ent	4.8	Χ	Χ	Χ	Χ	Χ								
Behavior in rotation and tilt		4.9	Χ	Χ	Χ	Χ	Χ								
	at ambient temperature	4.10.1	Χ	Χ											
Starting torque without load	at low temperature b	4.10.2	Χ												
Without load	after limit temperature b	4.10.3		Χ											

<sup>&</sup>lt;sup>a</sup> The order is left to the initiative of the qualification authority. The tests apply to bearings with or without swaging grooves.

Table 7 — Destructive inspections and tests to be carried out for qualification

		- · · · a	Defined				Se	rial	num	ber	of sa	mpl	es			
Type of insp	ection	is and tests <sup>a</sup>	in subclause	1	2	3	4	5	6	7	8	9	10	11	12	13
Spherical surfa	Spherical surfaces conformity		4.11													Χ
	Permissible (C <sub>s</sub> )		4.12			Χ	Χ									
Under static	Radiai	Ultimate	4.13			Χ	Χ									
load		Permissible (C <sub>a</sub> )	4.12					Χ								
	Axial		4.13					Χ								
Under permissi dynamic ( $C_{25}$ )	ble <sub>at</sub>	low temperature b	4.44	Χ												
radial load + test on liner	at	high temperature b	4.14		Х											
Duty cycles	at amb	pient temperature	4.14 bis						Χ	Χ						
Liner	at (45	± 3) °C <sup>b</sup>									Χ	Χ				
compatibility	at (70	± 3) °C <sup>b</sup>	4.15										Χ	Χ		
with the fluids															Χ	

<sup>&</sup>lt;sup>a</sup> The order is left to the initiative of the qualification authority. The tests apply to bearings with or without swaging grooves.

b For these tests, an established qualification for such a diameter in a given range of bearings [see Tables 2 (a), 2 (b) and 2 (c)] applies automatically for all the other diameters and series.

For these tests, an established qualification for such a diameter in a given range of bearings [see Tables 2 (a), 2 (b) and 2 (c)] applies automatically for all the other diameters and series.

Table 8 (a) — Sharing of the tests to be carried out for qualification

Type of inspe	Type of inenections and tests	Defined in subclause					EN 45 amete		de									1 4539 neter						
			Subclause	12	15	17	22	25	30	35	40	45	50	12	15	17	20	25	30	35	40	45	50	55
Materials			4.1	Χ		Χ	Х		Χ		Χ		Χ	Х		Χ		Х		Х		Χ		Χ
Dimensions and tol	erances	3	4.2	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Χ		Χ		Χ
Masses			4.3	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Χ		Χ		Χ		Χ
Marking			4.4	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Χ		Χ		Χ		Χ
Surface appearance	е		4.5	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Χ		Χ		Χ		Χ
Hardness			4.6	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Χ		Χ		Χ
Surface roughness			4.7	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Χ		Χ		Χ		Χ
Surface treatment			4.8	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Χ		Χ		Χ
Behavior in rotation	and tilt		4.9	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Χ		Χ		Χ
Starting at amb		ient temperature	4.10.1	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Χ		Χ		Χ
torque without load	at low t	emperature	4.10.2	Χ																				
to que maneat read	after lin	nit temperatures	4.10.3	Χ																				
Spherical surfaces	conform	nity	4.11	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Х		Х		Χ
	Radial	Permissible ( $C_s$ )	4.12	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Χ		Χ		Χ
Static load	Nauiai	Ultimate	4.13	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Х		Х		Χ
Static load	Axial	Permissible ( $C_a$ )	4.12	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Х		Х		Χ
	Axiai	Ultimate	4.13	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Χ		Χ		Χ
Permissible	at ambi	ient temperature	4.14	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Χ		Χ		Χ
dynamic radial	at low t	emperature	4.16	Χ																				
load + test on liner	at high	temperature	4.17	Χ																				
Duty cycles	at ambi	ient temperature	4.14 bis	Χ		Χ	Χ		Χ		Χ		Χ	Χ		Χ		Х		Х		Х		Χ
1 (	at (45 ±	3) °C		Χ																				
Liner compatibility with the fluids	at (70 ±	= 3) °C	4.15	Χ																				
	at ambi	ient temperature		Χ																				

NOTE This table is given as an example. The order of ranges may be different but shall satisfy the requirements defined in 5.2 and in Tables 6 and 7. For a total qualification of the 2 ranges of bearings, it is required in the present example:

- 1 complete test;
- 21 partial tests;
- 17 "de facto" qualification.

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Table 8 (b) — Sharing of the tests to be carried out for qualification

Type of ins	spection	s and tests	Defined in						D	EN iam	453 eter		le											D		453 eter	9-2 cod	le					
			sub-	03	04	05	06	07	08	09	10	12	14	16	20	24	28	32	03	04	05	06	07	08	09	10	12	14	16	20	24	28	32
Materials			4.1	Χ		Χ		Χ	Х			Χ		Х		Х		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
Dimensions and	toleranc	es	4.2	Χ		Χ		Χ	Х			Χ		Х		Х		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
Masses			4.3	Χ		Χ		Χ	Х			Χ		Х		Χ		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Χ		Χ
Marking			4.4	Χ		Χ		Χ	Х			Χ		Х		Χ		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
Surface appeara	ance		4.5	Χ		Χ		Χ	Х			Χ		Х		Х		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
Hardness			4.6	Χ		Χ		Χ	Х			Χ		Х		Х		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
Surface roughne	ess		4.7	Χ		Χ		X	Х			X		Х		Х		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
Surface treatme	nt		4.8	Х		Χ		Χ	Х			Χ		Х		Χ		Χ	Х		Х		Χ	Х			Χ		Χ		Х		Χ
Behavior in rotation and tilt		4.9	Χ		Χ		Χ	Х			Χ		Х		Χ		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ	
0	at ambi	ent temperature	4.10.1	Χ		Χ		Χ	Х			Χ		Х		Х		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
Starting torque without load	at low to	emperature	4.10.2						Х															Х									
Without load	after lim	it temperatures	4.10.3						Х															Χ									
Spherical surfac	es confo	rmity	4.11	Χ		Χ		Χ	Х			Χ		Х		Х		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
	Radial	Permissible ( $C_s$ )	4.12	Χ		Χ		Χ	Х			Χ		Х		Χ		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
Static load	Raulai	Ultimate	4.13	Χ		Χ		Χ	Х			Χ		Х		Χ		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
Static load	Axial	Permissible ( $C_a$ )	4.12	Χ		Χ		Χ	Х			Χ		Х		Х		Χ	Χ		Χ		Χ	Χ			Χ		Χ		Х		Χ
	Axiai	Ultimate	4.13	Х		Χ		Χ	Х			Χ		Х		Х		Χ	Х		Χ		Χ	Χ			Χ		Χ		Х		Χ
Permissible	at ambi	ent temperature	4.14	Х		Χ		Χ	Х			Χ		Х		Х		Χ	Х		Χ		Χ	Χ			Χ		Χ		Х		Χ
dynamic radial $C_{25}$	at low to	emperature	4.16						Х															Χ									
+ test on liner	at high t	emperature	4.17						Х															Χ									
Duty cycles			4.14 bis	Х		Χ		Х	Х			Χ		Х		Х		Х	Х		Х		Χ	Χ			Χ		Χ		Х		Χ
Liner	at (45 ±	3) °C							Х															Х									
compatibility	at (70 ±	3) °C	4.15						Х															Χ									
with the fluids at ambient temperature		]						Х															Χ										

NOTE This table is given as an example. The order of ranges may be different but shall satisfy the requirements defined in 5.2 and in Tables 6 and 7. For a total qualification of the 2 ranges of bearings, it is required in the present example:

 <sup>1</sup> complete test;

 <sup>21</sup> partial tests;

 <sup>17 &</sup>quot;de facto" qualification.

Table 8 (c) — Sharing of the tests to be carried out for qualification

Type of insp	ections and tests	Defined in						ı		4538 leter																-003 cod						
		sub- clause	03	04	05	06	07	08	09	10	12	14	16	20	24	28	32	03	04	05	06	07	08	09	10	12	14	16	20	24	28	32
Materials		4.1	Χ		Χ		Х	Х			Х		Χ		Χ		Χ	Χ		Χ		Χ	Χ			Х		Χ		Χ		Χ
Dimensions and toler	ances	4.2	Χ		Χ		Χ	Χ			Χ		Χ		Χ		Χ	Χ		Χ		Χ	Χ			Х		Χ		Χ		Х
Masses		4.3	Χ		Х		Х	Х			Х		Х		Χ		Χ	Χ		Χ		Χ	Χ			Х		Χ		Χ		Х
Marking		4.4	Х		Χ		Х	Х			Х		Χ		Χ		Χ	Χ		Χ		Χ	Χ			Х		Χ		X		Х
Surface appearance		4.5	Χ		Х		Х	Х			Х		Х		Χ		Χ	Χ		Χ		Χ	Χ			Х		Χ		Χ		Х
Hardness		4.6	Х		Х		Х	Х			Х		Х		Χ		Χ	Χ		Χ		Х	Χ			Х		Χ		Х		Х
Surface roughness		4.7	Х		Х		Х	Х			Х		Х		Х		Χ	Χ		Χ		Χ	Χ			Х		Х		Х		Х
Surface treatment		4.8	Х		Х		Х	Х			Х		Х		Χ		Χ	Х		Χ		Χ	Χ			Х		Х		Х		Х
Behavior in rotation a	nd tilt	4.9	Х		Х		Х	Х			Х		Х		Χ		Χ	Х		Χ		Χ	Χ			Х		Х		Х		Х
	at ambient temperature	4.10.1	Х		Х		Х	Х			Х		Х		Χ		Χ	Χ		Χ		Χ	Χ			Х		Χ		Х		Х
Starting torque at zero load	at low temperature	4.10.2						Х															Χ									
after limit temperatures		4.10.3						Х															Χ									
Spherical surfaces conformity		4.11	Х		Х		Х	Х			Х		Х		Χ		Χ	Х		Χ		Χ	Χ			Х		Х		Х		Х
	Radial Permissible (C <sub>s</sub> )	4.12	Х		Х		Х	Х			Х		Х		Χ		Χ	Х		Χ		Χ	Χ			Х		Х		Х		Х
Chatia land	Ultimate	4.13	Х		Х		Х	Х			Х		Х		Χ		Χ	Х		Χ		Х	Χ			Х		Х		Х		Х
Static load	Axial Permissible (C <sub>s</sub> )	4.12	Х		Х		Х	Х			Х		Х		Χ		Χ	Х		Χ		Χ	Χ			Х		Х		Х		Х
	Ultimate	4.13	Х		Х		Х	Х			Х		Х		Х		Χ	Χ		Χ		Х	Х			Х		Х		Х		Х
Permissible dynamic	at ambient temperature	4.14	Х		Х		Х	Х			Х		Х		Χ		Χ	Х		Χ		Х	Χ			Х		Х		Х		Х
radial $C_{250}$	at low temperature	4.16						Х															Χ									
+ test on liner	at high temperature	4.17						Х															Х									
Duty cycles		4.14 bis	Х		Х		Х	Х			Х		Х		Χ		Х	Х		Χ		Х	Х			Х		Х		Х		Х
Low friction coefficient	a before / after Duty cycles tests	4.14											Х	Х														Х	х			
	at (45 ± 3) °C							Х															Х									
Liner compatibility with the fluids	at (70 ± 3) °C	4.15						Х															Х									
mar are naids	th the fluids at (70 ± 3) C at ambient temperature							Х															Χ									

NOTE This table is given as an example. The order of ranges may be different but shall satisfy the requirements defined in 5.2 and in Tables 6 and 7. For a total qualification of the 2 ranges of bearings, it is required in the present example:

- 1 complete test;
- 21 partial tests;
- 17 "de facto" qualification.
- <sup>a</sup> Two spherical plain bearing (EN 4538-003 or EN 4539-003) of the size 16 or 20 have to be tested.

Table 9 — Inspection and tests to be carried out for acceptance

Types of inspections and tests <sup>a</sup>	Defined in subclause	Sampling plan bc
Materials	4.1	Certificate of conformity of semi-finished products manufacturer
Dimensions and tolerances	4.2	10 % <sup>d</sup>
Marking	4.4	100 %
Curface annearons	4.5.1	10 % assembled <sup>d</sup>
Surface appearance	4.5.2	100 % unassembled
Hardness	4.6	1 % per heat treatment batch <sup>d</sup>
Surface roughness	4.7	5 % <sup>d</sup>
Surface treatment	4.8	1 % per heat treatment batch d
Behavior in rotation and tilt	4.9	100 %
Starting torque without load, at ambient temperature	4.10.1	100 %
Peel strength of the liner	4.16	1 % <sup>d</sup>
Bond integrity of the liner	4.17	1 % <sup>d</sup>

a The order is left to the initiative of the acceptance authority. These inspections can be carried out at the time of manufacture.

<sup>&</sup>lt;sup>b</sup> When the sampling is not 100 %, any defect found in the course of an inspection or test requires this inspection to be extended to 100 %.

<sup>&</sup>lt;sup>c</sup> May vary with the approval of the user or authority responsible for acceptance.

d Minimum two pieces.

# Annex A

(normative)

# Verification of permissible and ultimate static loads

# A.1 Permissible radial loads $(C_s)$

#### A.1.1 Principle

See Figure A.1 as an example.

#### A.1.2 Method

- Mount the bearing as shown in Figure A.1;
- Apply a radial pre-load equal to 5 % of  $C_s$  for 3 min;
- Set the dial gauge to zero;
- Continuously increase this pre-load (1 % per s) until  $C_s$  is obtained;
- Maintain load  $C_s$  for 3 min;
- Read off the value of the total deformation indicated by the dial gauge;
- Reduce the load continuously (1 % per s) to the pre-load value;
- Read off the value of the permanent deformation indicated by the dial gauge;
- Remove the pre-load;
- Check.

#### A.2 Ultimate radial static load

#### A.2.1 Test

This test follows that specified in A.1.

#### A.2.2 Principle

See Figure A.1.

#### A.2.3 Method

- Mount the bearing as shown in Figure A.1.
- Apply a radial load of 1,5  $C_s$  by increasing the load at a rate of 1 % per s.
- Maintain the load 1,5  $C_s$  for 1 min.
- Remove the load continuously at a rate of 1 % per s.
- Check.

# A.3 Permissible axial static load $(C_a)$

# A.3.1 Principle

See Figure A.2 as an example.

#### A.3.2 Method

- Mount the bearing as shown in Figure A.2;
- Apply a radial pre-load equal to 5 % of  $C_a$  for 3 min;
- Set the dial gauge to zero;
- Continuously increase this pre-load (1 % per s) until  $C_a$  is obtained;
- Maintain load  $C_a$  for 3 min;
- Reduce it continuously (1 % per s) to the pre-load value;
- Read off the value of the permanent deformation indicated by the dial gauge;
- Remove the pre-load;
- Repeat this operation after rotating one ring 180° in relation to the other.

#### A.4 Ultimate axial static load

#### A.4.1 Test

This test follows that specified in A.3.

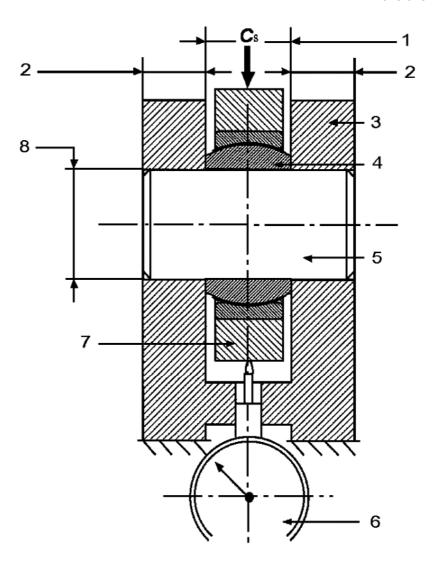
#### A.4.2 Principle

See Figure A.2.

#### A.4.3 Method

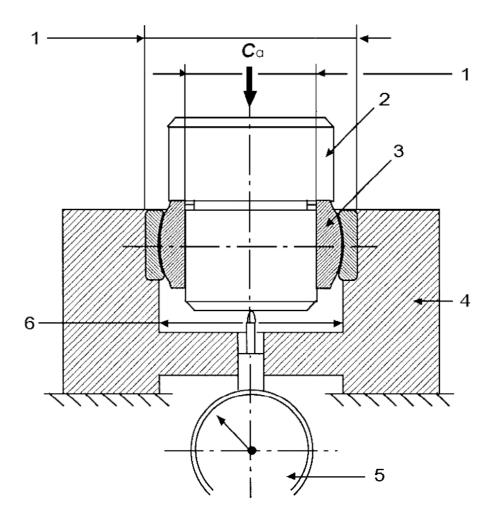
- Mount the bearing as shown in Figure A.2;
- Apply an axial load of 1,5  $C_a$ ;
- Remove the load;
- Check.

#### Dimensions in millimetres



- 1 Width of bearing inner ring + 0,10
- 2  $H \min = \emptyset$  spherical part  $-\emptyset d$
- 3 Frame 40 HRC min.
- 4 Bearing with self-lubricating liner
- 5 Pin in steel 50 HRC min.
- 6 Dial gauge
- 7 Test ring 50 HRC min.
- 8 Clearance range + 0,025

Figure A.1



- 1 Clearance range + 0,025
- 2 Mandrel
- 3 Bearing with self-lubricating liner
- 4 Support
- 5 Dial gauge
- 6 Ø spherical part + twice the thickness of the liner

Figure A.2

#### **Annex B**

(normative)

# Verification of dynamic radial loads ( $C_{25}$ )

# **B.1** Principle

See Figure B.1 as an example.

#### **B.2** Verification

#### B.2.1 Method

- Mount the bearing as shown in Figure B.1 without affecting its characteristics. The testing device shall be designed with the aim that the rotation during the test shall be effective at the liner level;
- Apply statically, for 15 min on the outer ring, the  $C_{25}$  load corresponding to the relevant test;
- Set the dial gauge to zero;
- Submit the bearing to the relevant test;
- Check the wear of the liner;
- After this checking, proceed to peel strength and bond integrity tests defined in 4.16 and 4.17.

#### **B.2.2** Testing at ambient temperature

Number of cycles: 25 000

Rate:  $(12 \pm 2)$  cycles/min Test load: 100 % of load  $C_{25}$ 

# **B.2.3** Testing at low temperature

Number of cycles: 25 000

Rate:  $(12 \pm 2)$  cycles/min Test load: 75 % of load  $C_{25}$ 

Temperature to be maintained throughout the test: - 55 °C

The temperature may increase until -35 °C. In this event, stop the test to decrease the temperature to -55 °C then continue the test.

# **B.2.4** Testing at elevated temperature

Number of cycles : 25 000

Rate :  $(12 \pm 2)$  cycles /min Test load : 100 % of load  $C_{25}$ 

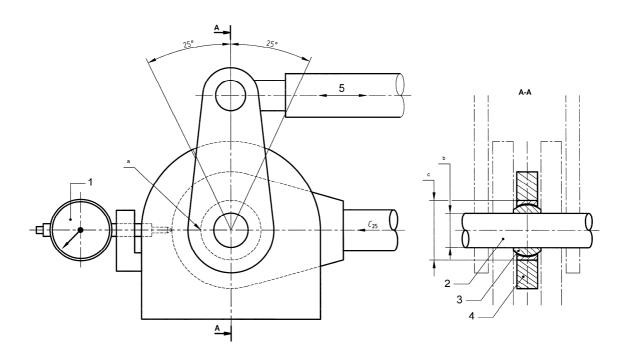
Temperature to be maintained throughout the test:  $(163 \pm 5)$  °C.

The heating, due to friction, could be balanced by adjusting the heating source.

# B.2.5 Test at ambient temperature after immersion

Number of cycles : 25 000

Rate :  $(12 \pm 2)$  cycles /min Test load : 75 % of load  $C_{25}$ 



- 1 Dial gauge
- 2 Pin in steel 50 HRC min.
- 3 Bearing with self-lubricating liner
- 4 Bearing support
- 5 Power unit
- a Location of the temperature gauge
- b Pin diameter = d nominal diameter  $\begin{pmatrix} + & 0.010 \\ & 0.025 \end{pmatrix}$
- Support diameter = D nominal diameter  $\begin{array}{c} + & 0,008 \\ & 0,005 \end{array}$

Figure B.1

# **Annex C**

(normative)

# Fluids — Essential characteristics

# C.1 Fuel for turbine aero engine

Flash point, min.:

Freezing point, max.:

Viscosity at 34,4 °C, max.:

Net calorific value, min.:

Total acidity, max.:

38 °C

- 50 °C

15 mm²/s

42,5 MJ/kg

0,015 mg KOH/g

Aromatics content, max.: 20 %
Olefins content, max.: 5 %
Total sulphur max.: 0,2 %

# C.2 Fluids for de-icing circuit

Nature: 96 % denatured isopropylalcohol

Density at 15° C, max.: 0,806 g/cm<sup>3</sup>

Distillation: 90 % distilled between 80 °C and 90 °C

Final distillation point, max.: 123 °C

# C.3 Hydraulic fluids

# C.3.1 Mineral fluid for hydraulic transmission - Type 5 mm<sup>2</sup>/s at 98,9 °C

Pour point, max.:  $-60^{\circ}$  C Flash point, min.:  $82^{\circ}$ C

Acid value, max.: 0,1 mg KOH/g

Color: red

Kinematic viscosity, min.: at 38 °C: 14 mm<sup>2</sup>/s

at – 40 °C: 500 mm<sup>2</sup>/s at – 54 °C: 3 000 mm<sup>2</sup>/s

# C.3.2 Phosphate of ester hydraulic fluid

Flash point: 182 °C Fire point: 215 °C

Acid value, max.: 0,04 mg KOH/g Kinematic viscosity, min.: at 98 °C: 3,85 mm<sup>2</sup>/s

> at 37 °C: 11,75 mm<sup>2</sup>/s at – 4 °C: 600 mm<sup>2</sup>/s at – 53 °C: 3 500 mm<sup>2</sup>/s

# C.4 De-icing and anti-icing fluids

ISO Type II (glycol base) according to ISO 11078.

# Annex D (normative)

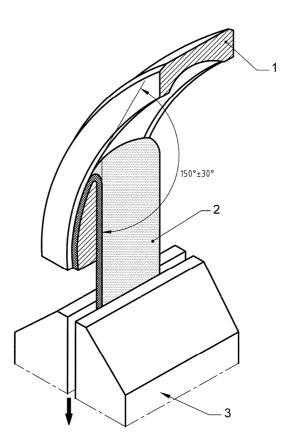
# Measurement of the peel strength of the liner

# D.1 Principle

See Figure D.1 as an example.

#### D.2 Method

- Cut the bearing.
- Hold, in an appropriate equipment, the half part of the outer ring which has not been subjected to a load.
- A blade, for example, may be used to initiate unsticking of the liner.
- Hold the extremity of the liner in the jaws of the clamping device which is equipped with a calibrated load cell.
- Apply a tension load in this device, with an angle of  $(150 \pm 30)^{\circ}$  to the bond surface, at a speed of (13 to 25) mm/min.
- Check the recorded values.



- 1 Outer ring of the bearing
- 2 Liner
- 3 Clamping device of the liner

Figure D.1

# Annex E

(normative)

# **Duty cycles**

# E.1 Principle

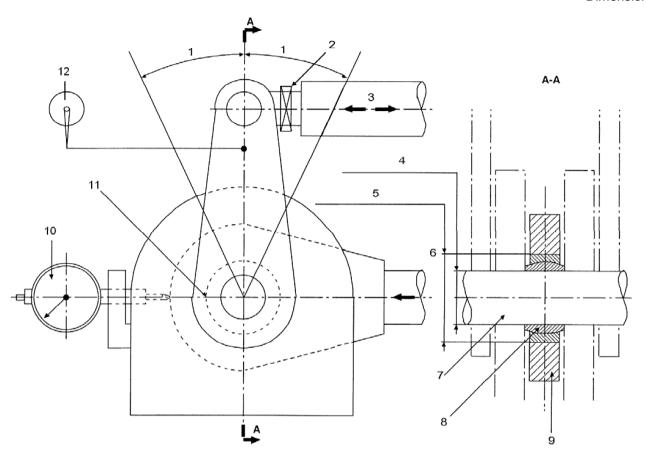
See example Figure E.1.

The duty cycle tests require the use of two served actuators:

- one to apply the radial load on the bearing;
- one to apply the rotation between the outer and the inner ring of the bearing.

#### E.2 Method

- Apply statically for 15 min on the outer ring, the load corresponding to the relevant test; (equivalent applied pressure 17,8 MPa);
- Set the dial gauge to zero;
- Submit the bearing to the relevant test;
- Check the wear of the liner at sufficient intervals to plot wear versus life in cycles;
- After this test, the friction coefficient shall be measured under applied pressure of 51,8 MPa and shall be lower than 0,18 in Tables 5 (a), 5 (b) and 5 (c);
- After test, proceed to peel strength and bond integrity tests defined in 4.16 and 4.17.



- 1 Rotation
- 2 Force detector
- 3 Actuator (position servoed)
- 4  $\emptyset$  pin =  $\emptyset$  *d* nominal  $^{+}_{-}$  0,010  $^{-}_{0,025}$
- 5  $\varnothing$  support =  $\varnothing$  D nominal  $\begin{pmatrix} + & 0,008 \\ & 0,005 \end{pmatrix}$

- 6 Actuator (force servoed)
- 7 Pin in steel 50 HRC min.
- 8 Bearing with self-lubricating liner.
- 9 Bearing support
- 10 Dial gauge
- 11 Location of the temperature gauge
- 12 Position transmitter

Figure E.1

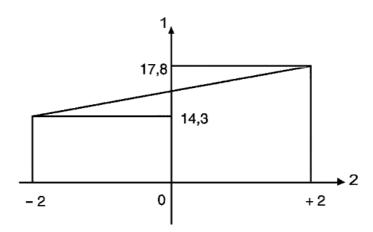
For each size of bearing the dynamic loads are obtained by multiplying the unit pressure by the projected surface area.

Load variation peak to peak is linear and proportional to the deflection. See Table E.1.

Table E.1

Rotation	Pressure applied	Cycle number	Maximum rotational speed
0	MPa		°/s
0 + 2 - 2	17,8 14,3	3 510 000	
0 + 4 - 4	19,6 12,5	450 000	
0 + 6 - 6	21,4 10,7	82 500	
0 +8 -8	23,2 8,9	31 500	
0 <sup>+ 10</sup> <sub>- 10</sub>	25,0 7,1	15 000	15
0 + 1 - 1	33,9 26,8	2 240 000	
0 + 3 - 3	41,0 19,6	135 000	
0 + 4 - 4	44,6 16,0	45 000	
0 + 6 - 6	51,8 8,9	30 000	

EXAMPLE See Figure E.2.



- 1 Pressure
- 2 Rotation

Figure E.2

# Annex F

(normative)

# Verification of dynamic radial loads ( $C_{250}$ )

# F.1 Principle

See Figure F.1 as an example.

#### F.2 Verification

#### F.2.1 Method

- Mount the bearing as shown in Figure F.1 without affecting its characteristics. The testing device shall be designed with the aim that the rotation during the test, shall be effective at the liner level;
- Apply statically, for 15 min on the outer ring, the  $C_{250}$  load corresponding to the relevant test;
- Set the dial gauge to zero;
- Submit the bearing to the relevant test;
- Check the wear of the liner;
- After this checking, proceed to peel strength and bond integrity tests defined in 4.16 and 4.17.

# F.2.2 Testing at ambient temperature

Number of cycles: 250 000

Rate:  $(12 \pm 2)$  cycles/min Test load: 100 % of load  $C_{250}$ 

#### F.2.3 Testing at low temperature

Number of cycles: 250 000

Rate:  $(12 \pm 2)$  cycles/min Test load: 75 % of load  $C_{250}$ 

Temperature to be maintained throughout the test: - 54 °C

The temperature may increase until -35 °C. In this event, stop the test to decrease the temperature to -54 °C then continue the test.

#### F.2.4 Testing at elevated temperature

Number of cycles: 250 000

Rate:  $(12 \pm 2)$  cycles/min Test load: 100 % of load  $C_{250}$ 

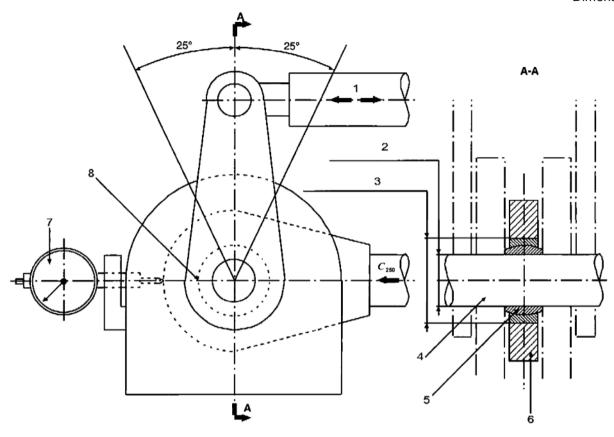
Temperature to be maintained throughout the test:  $(120 \pm 5)$  °C.

The heating, due to friction could be balanced by adjusting the heating source.

# F.2.5 Testing at ambient temperature after immersion

Number of cycles: 250 000

Rate:  $(12 \pm 2)$  cycles/min Test load: 75 % of load  $C_{250}$ 



- 1 Power unit
- 2 Ø pin = Ø d nominal  $\begin{array}{cc} + & 0.010 \\ & 0.025 \end{array}$
- 3 Ø support = Ø D nominal  $\begin{pmatrix} + & 0.008 \\ & 0.005 \end{pmatrix}$
- 4 Pin in steel 50 HRC min.
- 5 Bearing with self-lubricating liner
- 6 Bearing support
- 7 Dial gauge
- B Location of the temperature gauge

Figure F.1

# **Annex G**

(normative)

# Low friction coefficient

# G.1 Low friction coefficient

See Table G.1.

Table G.1

Friction coefficient <sup>a</sup>	Temperature range	Bearing pressure range
max. $\mu$		MPa
0,18	– 54 °C to 120 °C	10 to 120

<sup>&</sup>lt;sup>a</sup> The proof of the value of friction coefficient has to be furnished for the new bearing and after completion to lead the life time test (duty cycles).

Coefficient of friction to be measured before and completion of the duty cycles test at  $-54\,^{\circ}$ C,  $-30\,^{\circ}$ C,  $-10\,^{\circ}$ C and ambient temperature. For each temperature three measurements must be taken at 10 MPa, 60 MPa and 120 MPa pressure.

Two spherical plain bearings of the size 16 or 20 have to be tested.

The maximum value of coefficient of friction is  $\mu = 0.18$ .

Coefficient of friction will be calculated as follows:

$$\mu = T/(R \times F)$$

where

F Radial load F max. = Protected surface area (mm<sup>2</sup>)  $^{3)} \times$  Pressure (MPa);

T Measured torque under the load F;

R Radial of the ball.

Both bearings subjected to dynamic test must be tested.

<sup>3)</sup> See Table 2 of EN 4538-003 and EN 4539-003.



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